THE EAST COAST "BACKDOOR" FRONT OF MAY 16-20, 1951

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INTRODUCTION

The first heat wave that occurs in the late spring over the Mid-Atlantic States is frequently broken by the passage of a "backdoor" cold front. The term, "backdoor front," is used by the meteorologist to identify a cold frontal passage from an easterly or northerly direction rather than from the more normal westerly direction.

The meteorological conditions producing this phenomenon are usually stagnation and intensification of an anticyclone to the northeast of the forecast region. Frequently, the deceleration or stagnation is accompanied by a reorientation of the High cell and a geometric change from perhaps a nearly circular High to one that has a major axis in an east to west direction.

The favorite geographical regions for the occurrence of "backdoor" cold fronts in the United States are the east slopes of the Rocky Mountains and the east slopes of the Appalachian Mountains. In these regions the cold air banks up against the mountains and is forced southward, or southwestward, at a wide angle across the isobars in the area. Thus, the cold air advances farther south than it would ordinarily if the orographic effect were absent.

Along the east coast during the spring months, Polar air that moves southeastward from Canada and out over the cold coastal waters will arrive practically unmodified upon its entrance along the coast of the United States. The associated low temperatures produce marked contrasts in daily temperature readings as this cold air replaces the warm tropical, or the warm return flow connected with a warm ridge or High cell over the Southeastern States.

The vigor of the movement of the surface cold air from the northeast is dependent upon the pattern of the air flow in the mid-troposphere. For the "backdoor front" to advance very far to the south the flow at the 500-mb. level over the area concerned must be from a northerly direction. For the east coast a persistent flow from the northeast at the higher levels is especially favorable.

On May 16, 1951, maximum temperatures rose to near 90° F., from New England southward to Florida. At that time, a cold front was situated along the 45th parallel from Maine to Michigan. The following discussion will describe how a favorable air flow was created. This flow coupled with the air mass in the lower atmosphere pulled the cold air southward into Georgia, and thereby put an end to the incipient heat wave which was advancing upon the Atlantic Coastal States.

PRECEDING SITUATION

Early on May 14, 1951, a sharp, V-shaped, cold trough, at the 500-mb. level, moved eastward over the ocean immediately adjacent to the Atlantic Coastal region. Analysis of the 1500 GMT chart (not shown) for that date revealed that during the previous 12 hours, the sharp wind shear weakened considerably in the zone over Maine to Nova Scotia. As a result, the northern end of the trough continued eastward. In the southern end a large cut-off Low formed with a center 50 to 70 miles east of stationary weather ship "H" (latitude 36° N., longitude 70° W.). As a consequence, the wind pattern associated with the trough was altered. Winds continued from a westerly direction over the northern end of the trough, while to the south they slowly took on the characteristic cyclonic circulation. During the next 2 days the cold cut-off Low developed in intensity, expanded in area and moved southwestward.

At the 700-mb. level on May 15, a large High cell was centered over Kentucky. Most of the eastern United States was covered by this system. As with the upper level, a sharp trough moved eastward off the coast of the United States. This trough developed a cut-off Low about midway between Bermuda and ship "H", 24 hours after the detection of the cut-off Low at the 500-mb. level. During the next 2 days this new Low moved southwestward to within about 100 miles of the Bahama Islands.

Concurrently, the surface weather maps reflected these upper air changes. On May 15, an elongated High cell divided in the vicinity of Maryland; one portion moved out to sea while the other moved to eastern Kentucky and became stationary. Meanwhile, an open wave on the 15th moved from northwestern Ontario to northeastern Quebec. During the next 24 hours this storm moved east into the Atlantic Ocean.

OPENING SITUATION

In the early morning of May 16, a mass of cold air was situated behind the 700-mb. trough over southeastern Canada. The strongest advection of cold air was directed toward the southeast across Quebec. Elsewhere behind the front the cold air advection was weaker with the temperature gradient orientated perpendicular to the stream of northwest winds. The gradient was of the order of 5° C. per 3.5° latitude.

A broad current of air moved eastward, at the 500-mb. level, over southeast Canada with a southern limit over

Massachusetts. The cut-off Low over the ocean caused northeast winds from Long Island Sound southward along the Atlantic Seaboard.

On the surface map for 0630 GMT, May 16 (fig. 1), a cold front associated with the 700-mb. trough extended southwestward from the Low centered over northeastern Quebec. This front curved over southern Quebec and extended westward over Lake Superior to North Dakota. The southwest winds to the south of the storm center were augmented and further extended in area by the return flow of warm air from the large, warm High over the eastern United States.

The warm weather associated with this flow invaded a wide area from the Ohio Valley eastward and northward to include the Mid-Atlantic and the New England States. The onset of this flow caused maximum temperatures, on the 15th, to range from the middle to high eighties from the Gulf Coast to southern Quebec. This warming continued on the 16th, with maximum temperatures for the day of 90° F. at Portland, Maine, 91° at Boston, Mass., 90° at Philadelphia, Pa., and 89° at Washington, D. C. Portland with a reading of 90° at 1330 EST, had a frontal passage shortly before 1930 EST, following which the temperature dropped sharply to a reading of 66° at 1930 EST.

During May 17 the surface cold air mass (fig. 2), moved southeastward across New England and the Canadian Maritime provinces, at a rate slightly greater than twice the southward movement of the Great Lakes portion of the front. This was clearly a reflection of the situation aloft. Where there was strong cold advection the front moved rapidly and where there was weak cold advection the surface front moved more slowly.

The 1500 GMT 700-mb. chart of May 17 (fig. 3) was selected to show the location of the intersection of the cold air boundary with the 700-mb. level. Additionally, the chart illustrates the flow pattern above the surface front. The isotherms continued nearly parallel to the wind flow in the cold air with the exception of the area behind the leading edge of the cold front over the ocean east of Labrador. The temperature gradient, orientation and strength remained unchanged over southeastern Canada. This flow arrangement was not viewed as conducive to any marked southward movement of the cold air. A broad band of weak westerlies dominated the area south of Nova Scotia to southern Virginia. Over the South Atlantic States the winds were easterly in response to the cold Low over the ocean.

The hot weather continued on the 17th south of the cold front with typical readings of 90° at Philadelphia, Pa., 91° at Harrisburg, Pa., and 88° at Washington, D. C. Pronounced cooling followed in the wake of the advancing cold air. Characteristic of the change were Boston, Mass., with a high temperature of 67°, a drop of 24° from the 16th, and Portland, Maine, with a maximum of 62°, a 28° change. The frontal passage at New York City dropped the temperature from an early afternoon high of 80° to a reading of 61° by 1930 EST.

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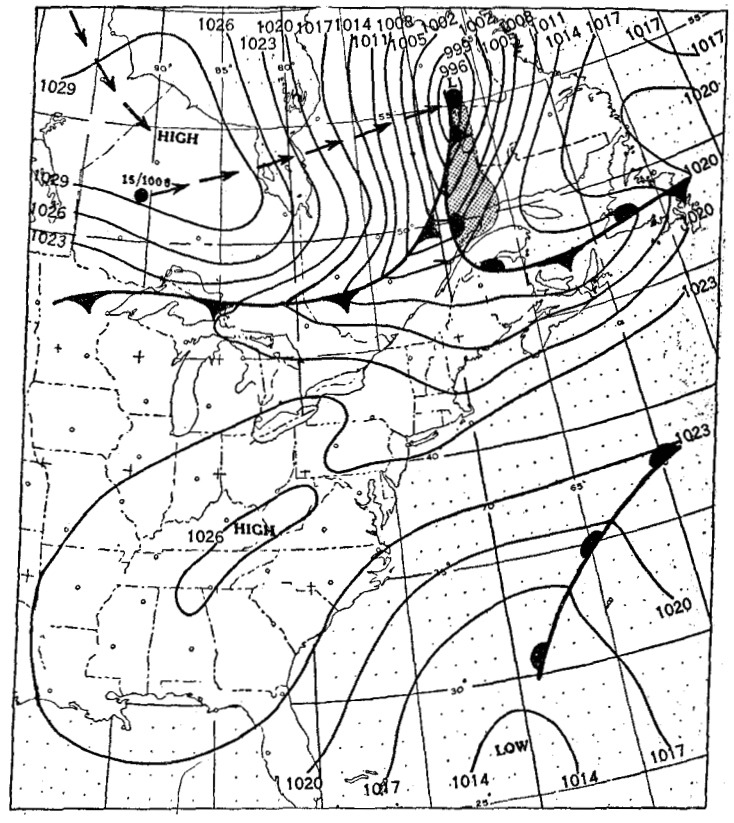

FIGURE 1.—Surface weather chart for 0630 GMT, May 16, 1951. Shading indicates areas of active precipitation. Dots indicate previous 24-hour positions. Numbers to the right of each dot indicate the day and the central pressure (mb.) of the system on that date. Arrows indicate path taken by the center.

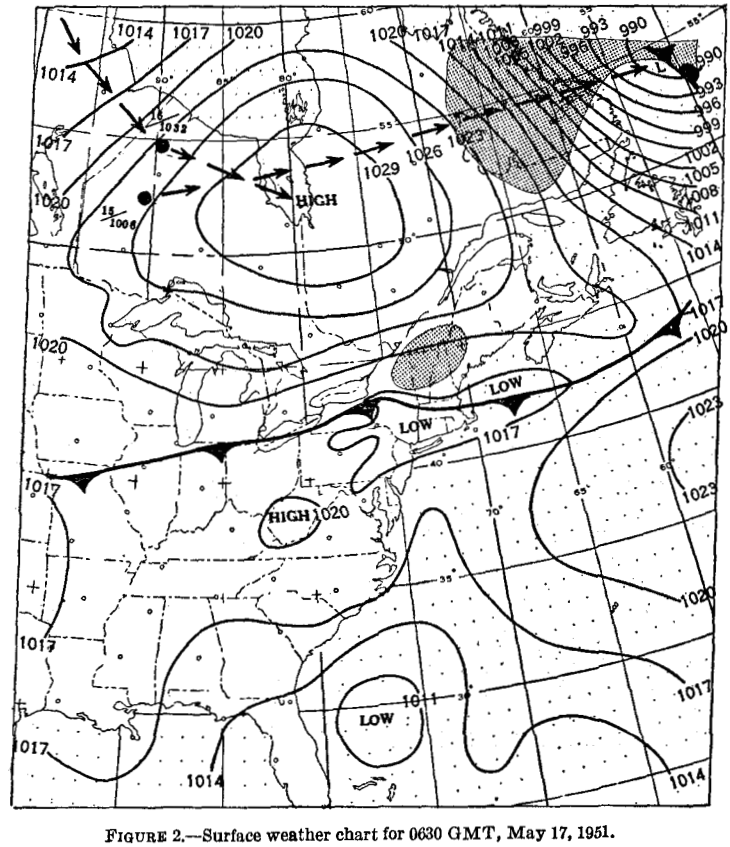

FIGURE 2.—Surface weather chart for 0630 GMT, May 17, 1951.

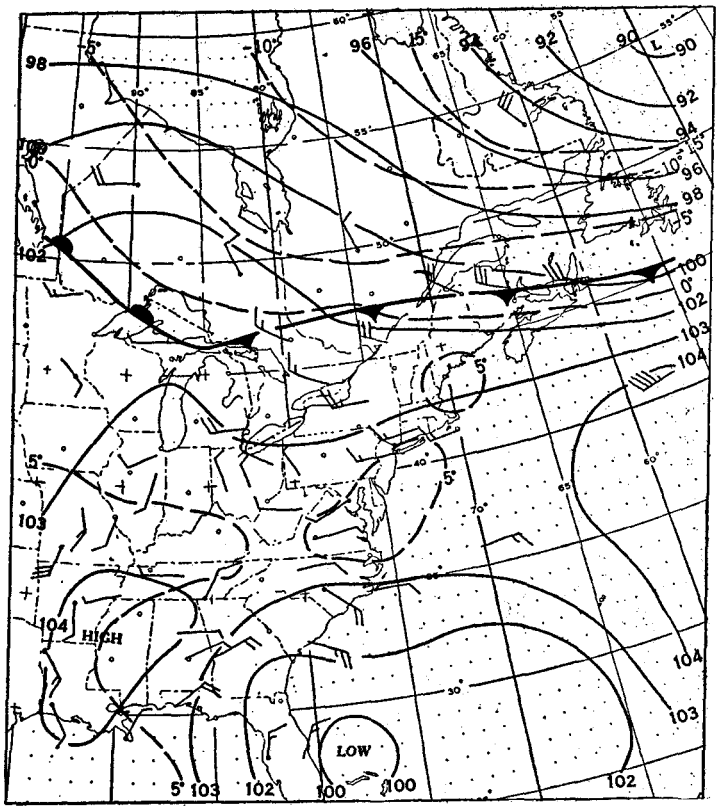

FIGURE 3.—700-mb. chart for 1500 GMT, May 17, 1951. Contours (solid lines) are labeled in hundreds of feet. Isotherms (dashed lines) are drawn for intervals of 5° C. Barbs on wind shaft show wind speed in knots (pennant=50 knots, full barb=10 knots, and half barb=5 knots).

DEVELOPING SITUATION

During the 12 hours preceding the 0300 GMT chart May 18 (fig. 4), the large elongated cold trough at the 700-mb. level had rotated counterclockwise with the southern end acting as a pivot. This cold Low, in conjunction with the ridge inland and to the west of the Appalachian Mountains, produced northeast winds from Long Island Sound southward along the coast. Of note was the belt of 20- to 40-knot winds from central Virginia southwestward along the coastal plain. This flow of northeast winds above the cold air contributed to the movement of the surface air mass down the coast. Examination of the contours at the 700-mb. level showed no appreciable change during the past 2 days. No cold air advection was evident over the Northeastern States.

On the 18th (fig. 5), the southeastward drifting high pressure center developed into an elongated east-west ridge, with the long axis coinciding with the 45th parallel. The surface trough, induced by the cyclonic circulation aloft, deepened and expanded in extent, with a center identified some 250 miles east of Cape Hatteras, N. C. The surface circulation around this Low acted to retard the ocean portion of the front to the north and northeast of ship "H". However, from north of ship "H" westward to western Pennsylvania, the cyclonic circulation acted to accelerate the southward push of the front. Consequently, the western portion of the front moved south-

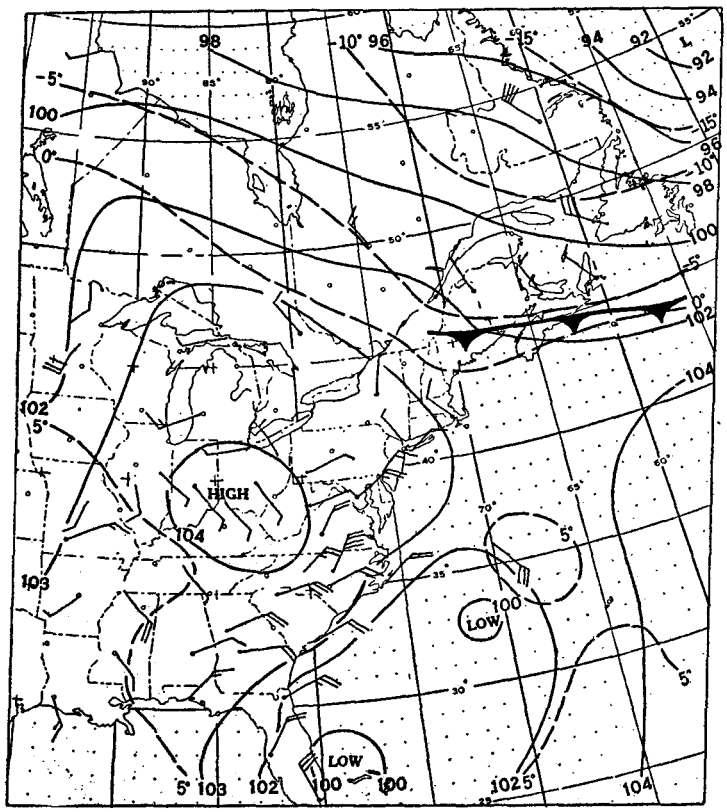

FIGURE 4.—700-mb. chart for 0300 GMT, May 18, 1951.

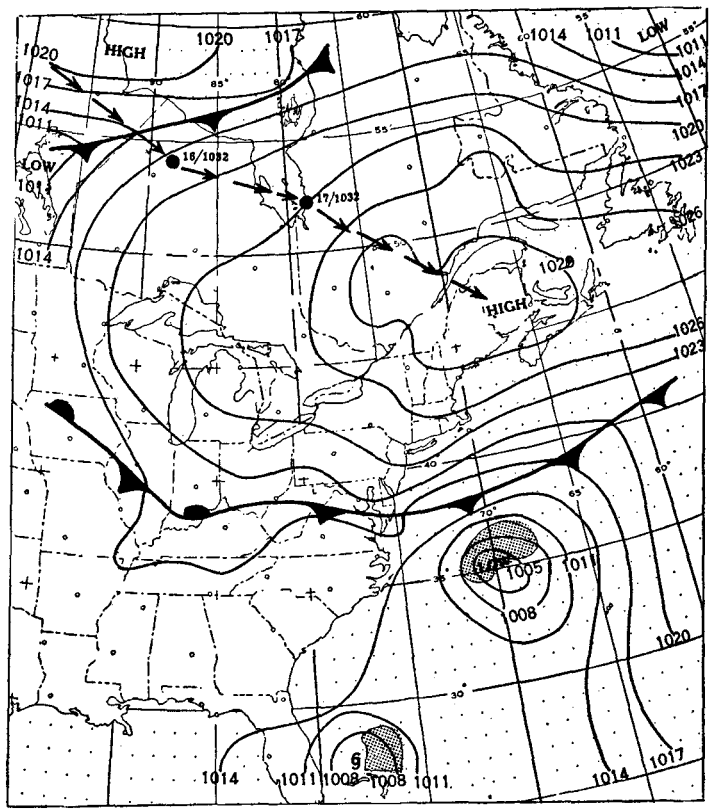

FIGURE 5.—Surface weather chart for 0630 GMT, May 18, 1951.

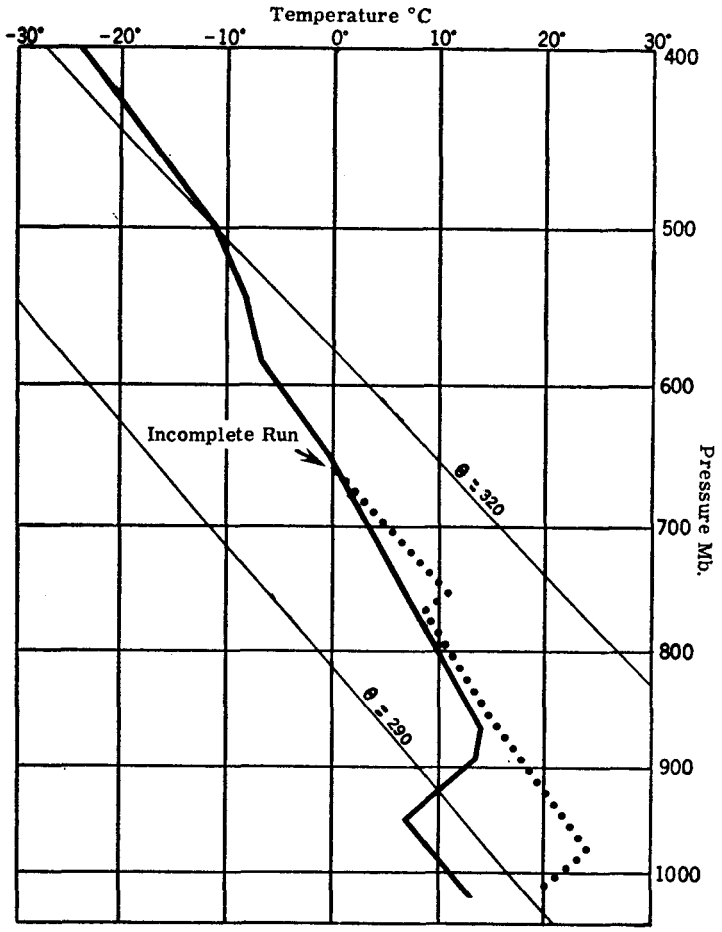

FIGURE 6.—Radiosonde observations (on a pseudo-adiabatic diagram) at Lakehurst, N. J., for 0300 GMT, May 17, 1951 (dotted line), and 0300 GMT, May 18, 1951 (solid line).

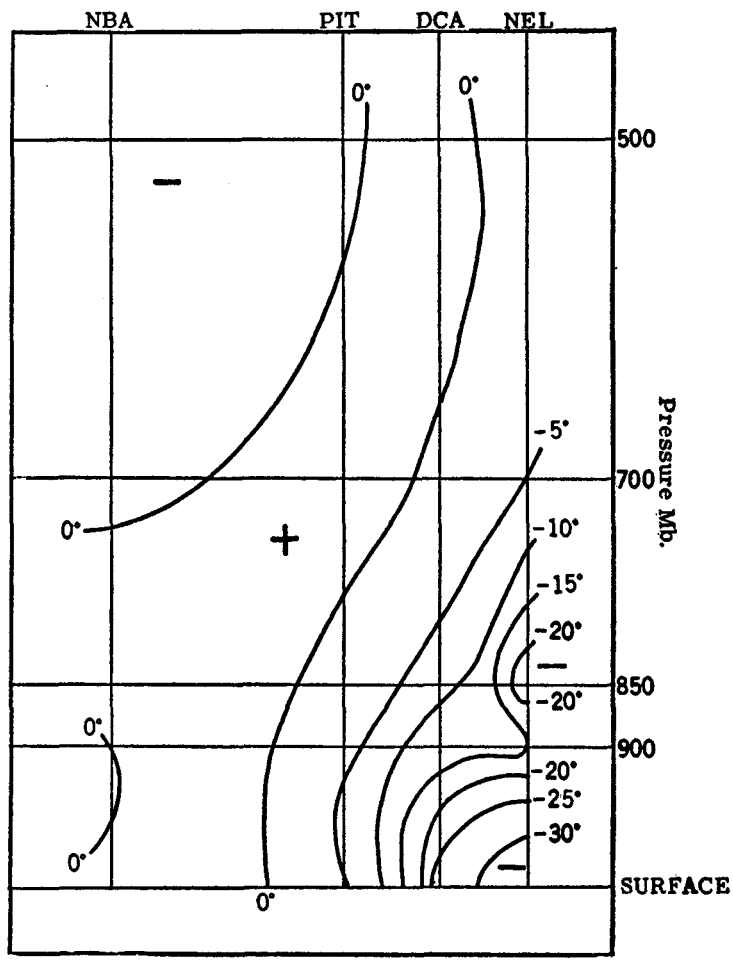

FIGURE 7.—Atmospheric cross-section showing 24-hour temperature change from 1500 GMT, May 17, to 1500 GMT, May 18, 1951. Isotherms (solid lines) are drawn for intervals of 5° F. Stations from left to right are: Nashville, Tenn. (NBA), Pittsburgh, Pa. (PIT), Washington, D. C. (DCA), and Lakehurst, N. J. (NEL).

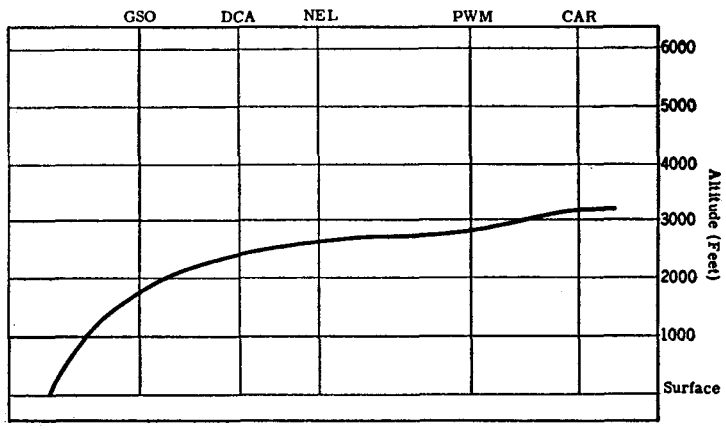

FIGURE 8.—Atmospheric cross-section showing North-South profile of cold air mass at 1500 GMT, May 18, 1951. Stations from left to right are: Greensboro, N. C. (GSO), Washington, D. C. (DCA), Lakehurst, N. J. (NEL), Portland, Maine (PWM), and Caribou, Maine (CAR).

ward twice as far as the eastern portion. The greatest 24-hour movement was directed south-southwestward over New Jersey and Maryland. During the day the wind velocity increased from Cape Cod to Maryland indicating added push to the front over Maryland.

The marked lowering of maximum temperatures continued to advance down the coast; Boston had 54°, New York City 67°, Philadelphia 65°, and Washington, D. C. 65°. The Lakehurst, N. J., upper-air soundings at 0300 GMT, May 17 and May 18 (fig. 6), attest to the sharp contrast between air masses. The shallow depth of the cold air was indicated by the pronounced cooling from the surface up to the 950-mb. level. The cross section from Lakehurst, N. J., to Nashville, Tenn. (fig. 7), illustrates the spatial distribution of the cooling in the free air during the 24-hour period from 1500 GMT, May 17 to 1500 GMT, May 18. Nashville was selected to represent the changes in the warm air mass. Inspection of the north-south cross section for 1500 GMT, May 18 (fig. 8), yields a clear idea of the profile of the cold air along the length of the air mass.

The cold Low at the 700-mb. level at 0300 GMT, May 19 (fig. 9), was orientated northeast to southwest, just off the Atlantic Coast from North Carolina to Florida. Inland the ridge split over the Ohio Valley forming one center over New York State and a second center over

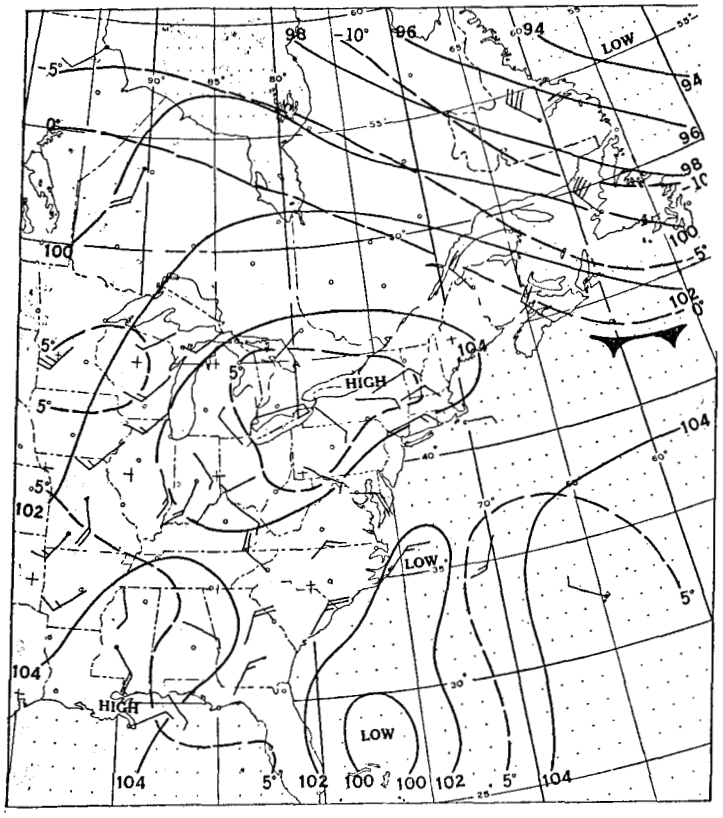

FIGURE 9.—700-mb. chart for 0300 GMT, May 19, 1951.

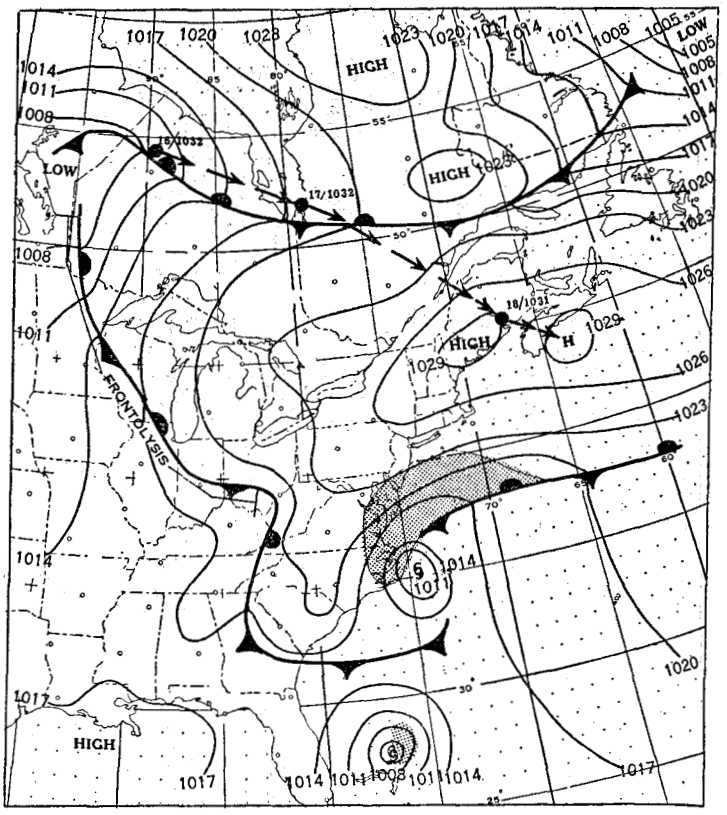

FIGURE. 10—Surface weather chart for 0630 GMT, May 19, 1951.

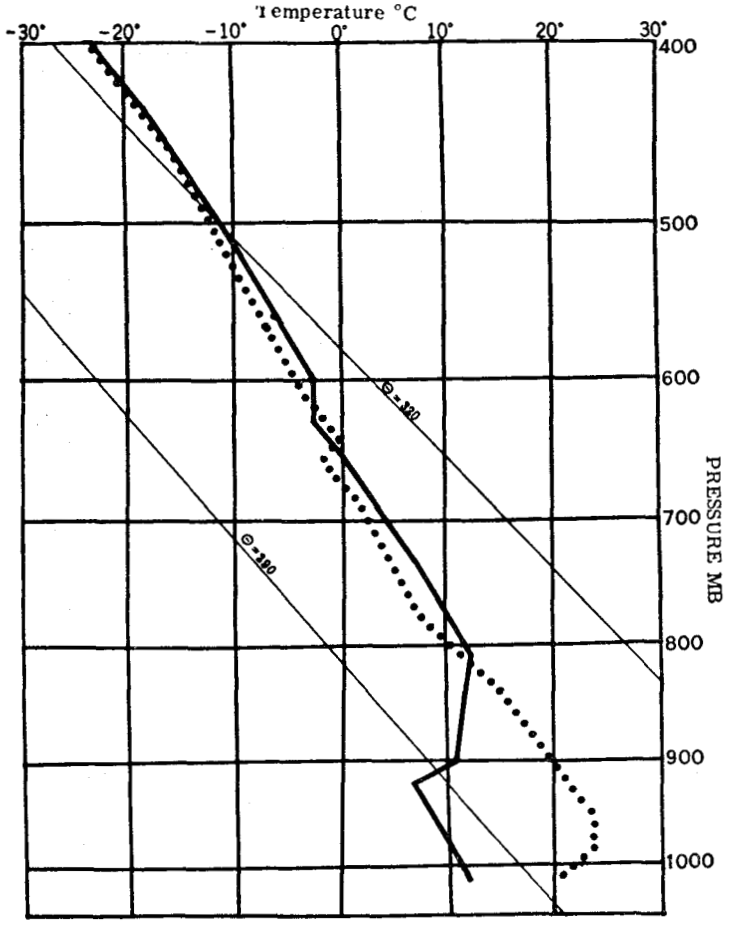

FIGURE 11.—Radiosonde observations (on a pseudo-adiabatic diagram) at Washington, D. C., for 0300 GMT, May 18, 1951 (dotted line), and 0300 GMT, May 19, 1951 (solid line).

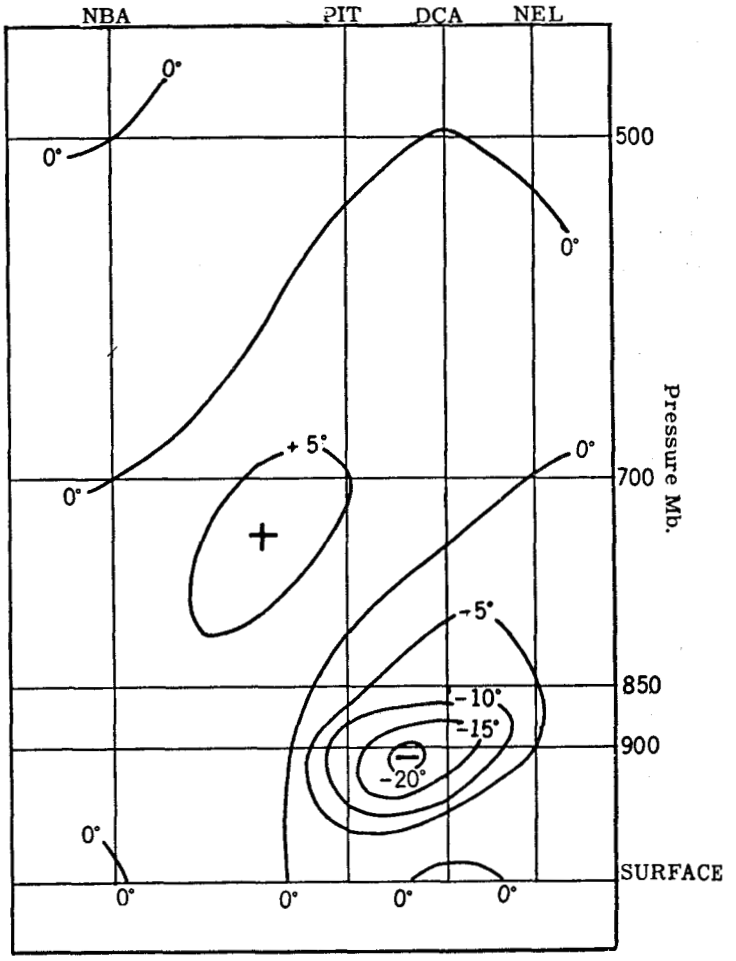

FIGURE 12.—Atmospheric cross-section showing 24-hour temperature change (° F.) from 1500 GMT, May 18, to 1500 GMT, May 19, 1951. (Stations are the same as those in fig. 7).

Mississippi. This rearrangement of flow pattern resulted in winds shifting to east from Washington, D. C., to Boston, Mass. In addition, the trough off the New England Coast rapidly disappeared as the High over New York State, and the northwestwardly advancing ridge from the oceanic High began to merge. As a consequence, east to southeast winds covered the area from Virginia to Massachusetts, and westward as far as Lakes Erie and Ontario. North of the newly forming ridge the winds were once more from a westerly direction.

On the surface, May 19 (fig. 10), the ocean portion of the front showed little movement from its position on the 18th, especially in the region 180 miles north of ship "H". The western boundary of the cold air ran from southwestern Pennsylvania, along the western slope of the Appalachian Mountains to northeastern Georgia.

During the day, temperatures remained below 70° from Maine to North Carolina. The soundings for 0300 GMT, May 18 and May 19 (fig. 11), show the depth and 24-hour cooling in the lower levels over Washington, D. C. The cross section (fig. 12), shows cooling during the 24 hours from 1500 GMT, May 18 to 1500 GMT, May 19. The greatest cooling took place at levels just above the surface.

With northeast surface winds both ahead of and behind the front, the cold air moved southward across Georgia. This flow, coupled with the southwest flow along the north side of the stalled Atlantic segment of the front, apparently contributed to the retardation of the movement of the ridge along the 45th parallel by virtue of the southwest air movement along the coast being greater than the southeast drift induced by the upper flow over the Nova Scotia area.

FINAL SITUATION

At the 700-mb. level on May 19, 1500 GMT (fig. 13), southeast winds had set in from North Carolina to Maine. At this level, as well as the 500-mb. level, the upper ridge gradually receded toward the southeast during the next 48 to 72 hours, thereby permitting the reestablishment of the more normal westerly wind regime over the region from Virginia northward.

The surface chart for May 20 (fig. 14), reflected these upper air changes. The air mass had become warmer, the front had become less well defined over the Southern States and had been wiped out over the New England States. Over the ocean the front persisted in just about the same position. The western limit of the cool air over the seaboard was identified by temperature differences over South Carolina and northward along the Appalachian Mountains to Pennsylvania. Although the air mass had modified considerably, maximum temperatures were below 70° along a narrow coastal strip from New York City to Cape Hatteras. Over the New England States, south winds had set in and the northern ridge had merged with the surface reflection of the upper warm ridge from the southeast. This was the last step in the history of the cold air which had moved far to the south in response to a peristent upper-air flow from the northeast and which in its turn disappeared when the upper-air pattern once more returned to normal.

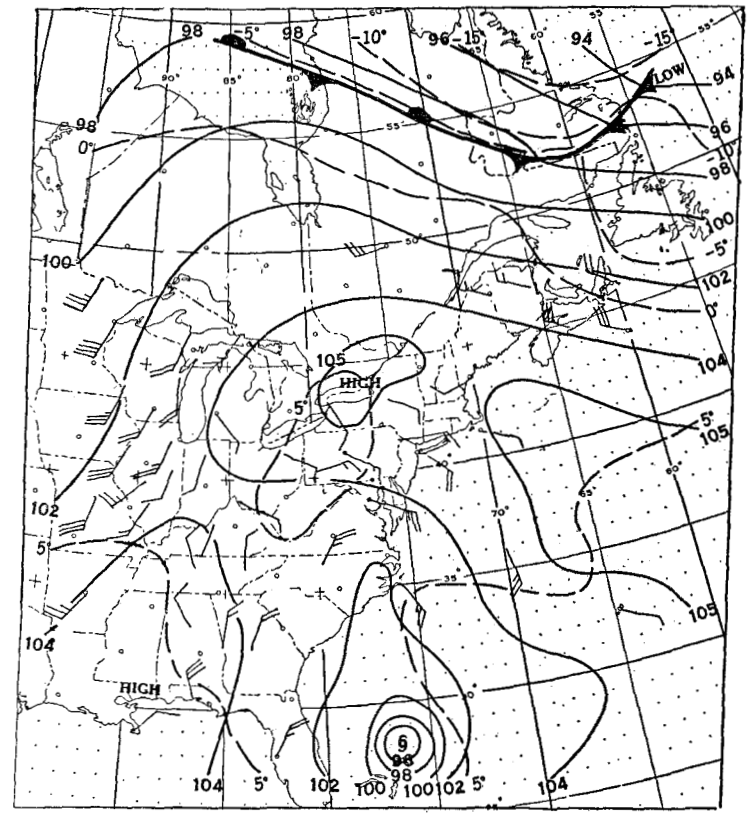

FIGURE 13.—700-mb. chart for 1500 GMT, May 19, 1951.

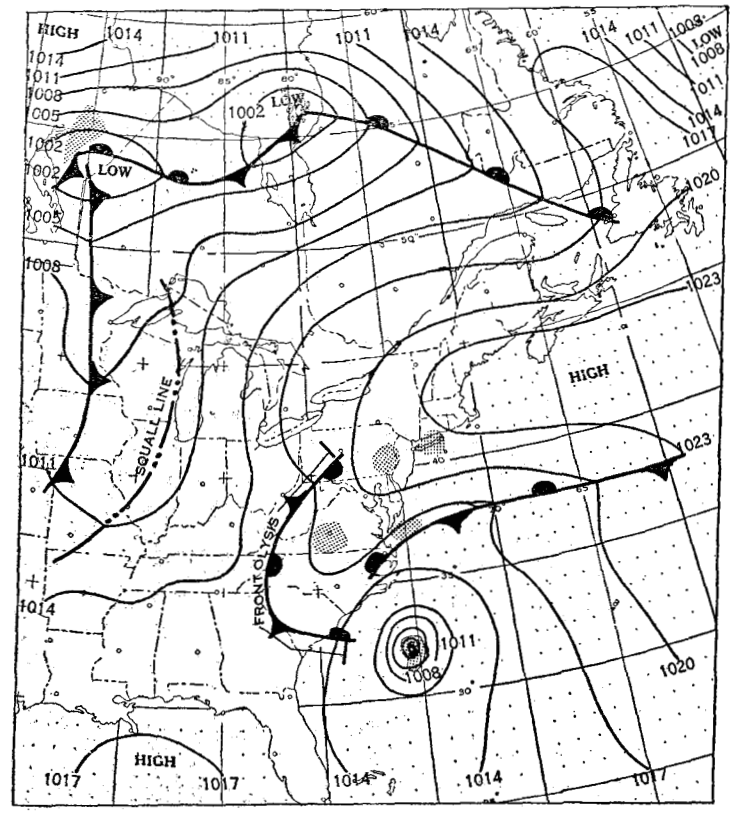

FIGURE 14.—Surface weather chart for 0630 GMT, May 20, 1951.

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